Global Economic Analysis of a U.S. Clean Energy Standard

L. Adkins, A. Golub, T. Hertel, and B. Mignone

Overview

Global economic analyses of climate policy face a challenging future. While comprehensive, top-down policies such as those foreseen under the Kyoto Protocol are highly amenable to analysis by global economic models, these policies have largely failed to get traction in the political arena. Instead, individual countries and regions are pursuing piecemeal approaches such as adoption of energy efficiency standards, technology mandates and industry-specific regulation. For example, in the United States, the Obama administration recently proposed a Clean Energy Standard (CES) for the electric power sector and plans to establish greenhouse gas (GHG) pollution standards for fossil fuel power plants and petroleum refineries.

Analysis of sector-specific energy policies can be challenging in "top down" global economic models that have rather simplistic representations of production technologies. Indeed, effective analysis of such policies often requires economists to turn to detailed sectoral models for insights regarding how something like a CES would affect key sectoral variables such as marginal cost and the optimal mix of inputs. This paper shows how the global impacts of a CES can be analyzed by combining a variant of the dynamic GTAP model, GDyn-E, with a detailed model of the U.S. energy sector: a version of the National Energy Modeling System (NEMS-PI). In so doing, we shed light on the implication of this type of policy for international investment and trade flows, quantifying the extent of investment and trade leakage associated with such a policy.

Energy system models like NEMS-PI and computable general equilibrium (CGE) models like GTAP have both been extensively used to study the energy and economic impacts of policies designed to mitigate greenhouse gas emissions. Each has its own set of strengths: energy system models typically have rich technology specifications and detailed representation of energy demands, while CGE models capture detailed linkages throughout the global economy. By linking NEMS-PI and GDyn-E, this analysis exploits the strengths of both "bottom up" and "top down" modeling frameworks to develop a more complete analysis of an illustrative energy policy. While the application of this model linkage is of interest in its own right in the context of the CES analysis, the paper makes a broader contribution by proposing a methodology for linking these frameworks in a more general way. So, as sector-specific climate and energy policies proliferate, this approach may become increasingly used by and useful for those within the GTAP community.

The CES analyzed in this paper is consistent with design principles proposed by President Obama in his State of the Union address in January 2011. This policy sets rising targets in the U.S. for the percentage of electricity that must be produced from qualified energy sources, including renewable energy, doubling this share from 40% today to 80% by 2035. In our two-stage modeling analysis, we first evaluate the CES in NEMS-PI. We then input NEMS-PI projections of energy prices, electricity fuel demands, and energy costs (prices) exogenously into GDyn-E, which propagates these energy system impacts throughout the economy. Importantly, we also impose the increase in electricity sector investment that NEMS-PI projects will occur as generation capacity from qualified technologies expands to satisfy CES targets. This enables us to examine the potential for positive supply chain impacts on upstream sectors that supply the electricity sector, something that macroeconomic analyses of climate and energy policies are often not equipped to capture.

Selected Preliminary Results

Investment leakage

In keeping with strengths of the dynamic GTAP framework, our analysis focuses on the international trade and investment implications of the CES. Given the emphasis of the model on international capital mobility, we begin with the investment leakage that ensues. Imposition of the CES reduces the economic efficiency of the power sector (not accounting for the externalities associated with coal combustion) and raises costs of electricity and natural gas in the U.S. economy. In the absence of comparable policies elsewhere in the world, both of these factors serve to lower rates of return to capital in the U.S. economy, resulting in leakage of investment to other countries. Figure 1 reports the cumulative deviation of regional capital stocks from baseline levels due to implementation of the CES. By 2035, U.S. capital stock is projected to be about 1% smaller than in the baseline – amounting to $600 billion less capital stock in that final year of our simulation. The main beneficiaries (in absolute terms) are the EU, Japan, Brazil and Central Europe. China's capital stock is actually reduced due to the strong intermediate trade linkages to the energy-intensive sectors in the U.S. economy.

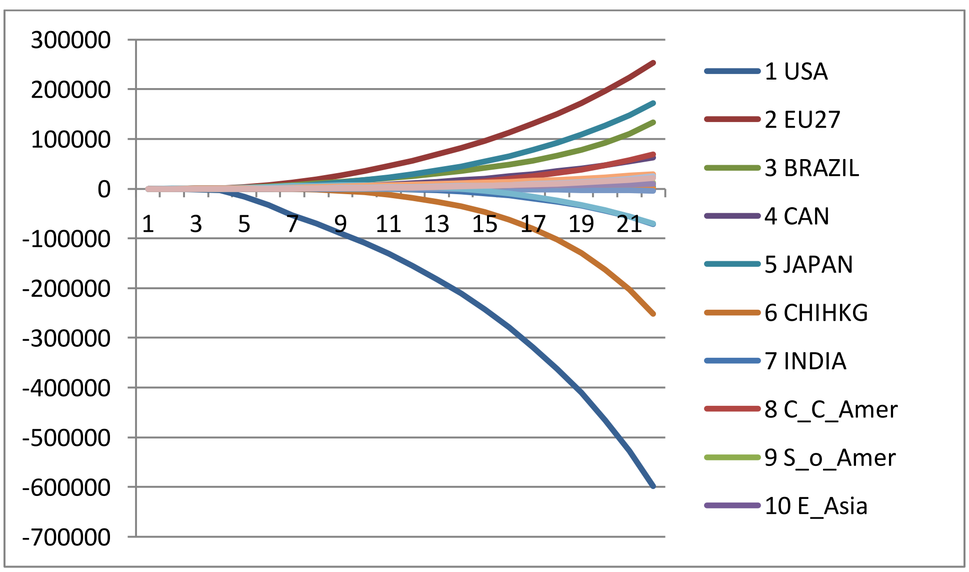

Figure 1. Evolution of regional capital stocks: deviations from baseline in millions of $U.S.

Regional trade balances

With only modest changes in savings and foreign income payments, reduced investment in the U.S. economy must be reflected in the trade balance, and so the U.S. must export more goods and services under a CES scenario, while those economies experiencing increased investment reduce net exports, relative to baseline. Figure 2 reports the evolution of the regional trade balances for a subset of the regions in the model. By 2035, U.S. net exports of goods and services are $7.6 billion higher compared to baseline as a result of the CES. The largest reductions in net exports are for the EU, Brazil and Japan. China's trade balance shows a modest improvement, due to the reduced investment inflow into that region.

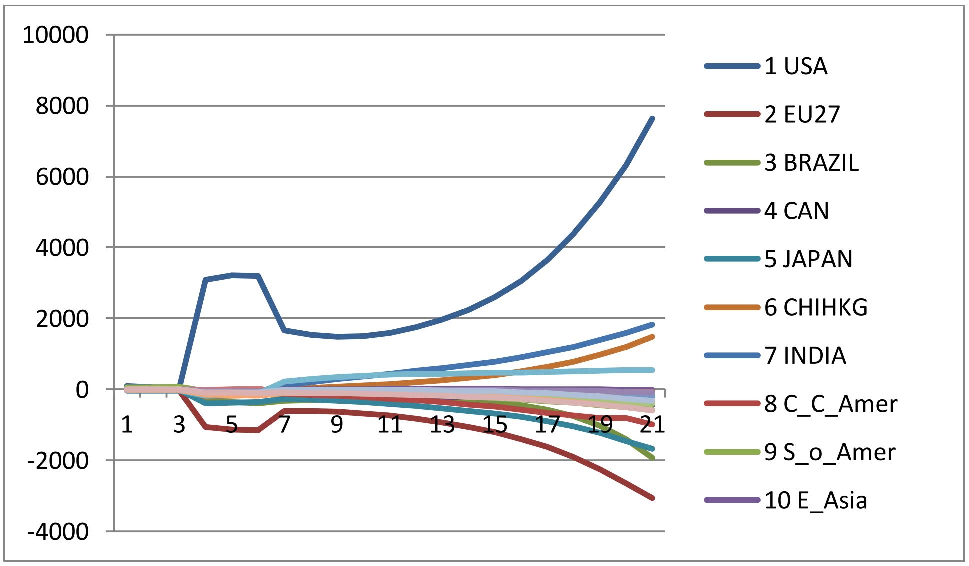

Figure 2. Evolution of regional trade balances: deviations from baseline in millions of $U.S. (positive numbers reflect a rise in net exports)

U.S. sectoral trade balances

The increase in U.S. exports, relative to imports, driven by reduced investment is not spread uniformly across sectors in the U.S. economy. Figure 3 shows the U.S. sectoral trade balances under the CES. Increased use of natural gas for power generation – a key outcome of the CES as proposed – results in a decline in net exports of gas. The cement and other non-metallic minerals sector also experiences a deterioration in its trade balance, as this is a key capital input, along with vehicles, construction and other machinery and equipment, to the power sector as it builds additional capacity. Energy-intensive manufactures sees a deterioration in its trade balances due to rising power and natural gas costs. Consistent with the overall improvement in the U.S. trade balance, net exports rise for other sectors, with the largest increases coming in services, light manufactures, agriculture, food and energy products. The increase in exports of the latter (coal in particular) is driven by reduced consumption in the electric power sector.

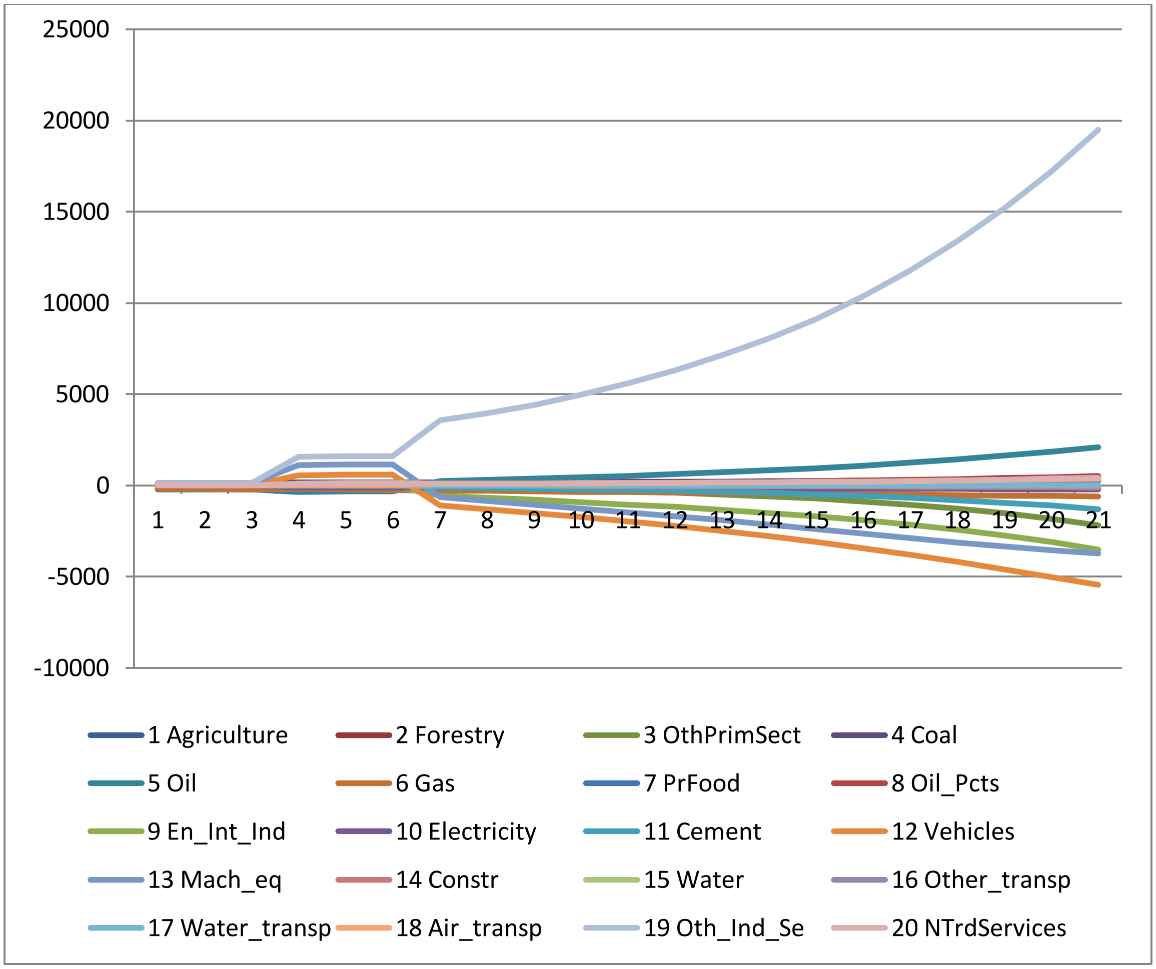

Figure 3. Evolution in U.S. sectoral trade balances: deviations from baseline in millions of $U.S.

References

Burniaux, J.. 2001. “International Trade and Investment Leakage Associated with Climate Change Mitigation”. Center for Global Trade Analysis. Purdue University, West Lafayette, IN.

Burniaux, J. and T. Truong. 2002. "GTAP-E: An Energy-Environmental Version of the GTAP Model", GTAP Technical Paper No. 16, Center for Global Trade Analysis. Purdue University, West Lafayette, IN.

Chappuis, T., T. Walmsley, and A. Winston. “An updated global baseline for the Dynamic GTAP model”. Paper presented at the Fourteenth Annual Conference on Global Economic Analysis, Venice, Italy, June 16 - 18, 2011.

Golub, A. and R. McDougall, 2006. “New Household Saving Behavior in the Dynamic GTAP model”. Paper prepared for the presentation at the Ninth Annual Conference on Global Economic Analysis, Addis Ababa, Ethiopia, June 15 - 17, 2006.

Ianchovichina, E. and R. McDougall, 2001. Structure of Dynamic GTAP. GTAP Technical Paper 17, Center for Global Trade Analysis, available on line at www.gtap.org.

McDougall, R. and A. Golub. 2007. “GTAP-E Release 6: A Revised Energy-Environmental Version of the GTAP Model", GTAP Research Memorandum No. 15, Center for Global Trade Analysis. Purdue University, West Lafayette, IN, USA.